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Further Evaluation of Prompting Tactics for Establishing Intraverbal Responding in Children With Autism

Einar T. Ingvarsson,
University of North Texas, Child Study Center, Fort Worth
Duy D. Le, Child Study Center, Fort Worth

We compared prompting tactics to establish intraverbal responding (question answering) in four boys with autism. Based on the results of intraverbal, textual, echoic, and tact pretests, we compared vocal and picture prompts with three participants, and textual, vocal, and picture prompts with one participant. We also evaluated repeated acquisition with different question sets, and included a concurrent-chains arrangement, in which initial link selections determined which prompting procedure occurred in the terminal link. All the prompting procedures were effective in establishing intraverbal responding, but vocal prompts resulted in the fewest trials to criterion for all four participants during the initial prompt comparison. However, the results were less consistent for the second comparison. The concurrent chains arrangement revealed a clear preference for picture prompts for one participant, but the results for the others were inconclusive.

Key words: autism, concurrent-chains assessment, intraverbal training, prompting procedures, transfer of stimulus control, verbal behavior

Intraverbal responses are evoked by antecedent verbal stimuli and maintained by nonspecific reinforcement (Skinner, 1957). Intraverbal control is involved in many common behaviors, such as answering questions, carrying on conversation, intraverbal categorization, singing songs, reciting the alphabet, and vocal fill-in-the blank tasks. These skills play a large role in children's social interactions; therefore the establishment of intraverbal responding is an important educational goal for children with autism and other developmental disabilities (Sundberg, 2008; Sundberg & Sundberg, in press). Yet, research studies on instructional strategies to establish intraverbal responses have been relatively scarce compared with studies on other verbal operants (e.g., tacts and mands).

Previous research has shown that transfer-of-stimulus control procedures are frequently an effective approach to teach intraverbals (e.g., Miguel, Pétursdóttir, & Carr, 2005). These procedures involve the presentation of a stimulus that already evokes the desired response, and thus serves as a prompt. In intraverbal training programs, the prompt might be presented immediately following or concurrently with the target verbal antecedent stimulus. The prompt is then faded with the goal of transferring stimulus control to the target verbal antecedent stimulus (e.g., a question). The prompt can be faded by introducing a delay between the verbal antecedent stimulus and the prompt (e.g., Ingvarsson & Hollobaugh, 2010), or by gradually removing parts of the stimulus prompt (e.g., Finkel & Williams, 2001).

Previous research has demonstrated the effectiveness of at least three prompting tactics to establish intraverbal responses: (1) textual prompts, in which the target intraverbal response is presented in textual format along with or immediately following the verbal antecedent stimulus (e.g., Finkel & Williams, 2001); (2) vocal prompts (sometimes referred to as echoic prompts), in which a vocal model is presented following the target verbal antecedent stimulus (e.g., Ingvarsson, Tiger, Hanley, & Stephenson, 2007); and (3) picture prompts (sometimes referred to as tact prompts) in which a picture representing the target response is presented along with the verbal antecedent stimulus

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Address correspondence to Einar T. Ingvarsson, Department of Behavior Analysis, 1155 Union Circle, Box 310919, University of North Texas, Denton, TX 76203-0919 (einar.ingvarsson@unt.edu).

(e.g., Goldsmith, LeBlanc, & Sautter, 2007). In each case, the goal of training is to utilize pre-existing textual, echoic, or tact relations in a transfer-of-control procedure. Thus, the student must have one or more of these repertoires well-established for transfer-of-control intraverbal training to be feasible. When two or more of these repertoires are in place, the behavior analyst has a choice of which prompting tactic to use.

Only a handful of published studies have compared prompting tactics during intraverbal training, and most have compared the use of textual and vocal prompts. Both Finkel and Williams (2001) and Vedora, Meunier, and Mackay (2009) found that textual prompts were more efficient (i.e., required fewer teaching trials or sessions until mastery was reached) than vocal prompts in establishing intraverbal responding. A total of three children with a diagnosis of autism participated in these two studies. However, recent research by Cook, Keenan, Ahearn, and Miguel (2010), conducted with six children with autism, found that vocal prompts were generally either more effective or equally effective when compared with textual prompts in establishing intraverbal responding. These results suggest that prompt efficiency is not fixed or absolute, and that learning histories might influence the efficiency of particular tactics of stimulus control transfer. For instance, it is possible that prior experience with repeated use of vocal prompts might facilitate subsequent transfer of stimulus control from one vocal response to another vocal response (i.e., echoic-to-intraverbal transfer). A recent study by Coon (2010) lends some support to this notion. This author conducted intraverbal training using vocal and picture prompts with four typically developing preschool children, and found that the most efficient prompt type at a given time was likely to be determined by recent learning history.

Although textual prompts are appropriate for students whose textual responding is relatively strong, comparing vocal and picture prompts might be more relevant for other populations. These prompting tactics are particularly relevant to the design of early and intensive behavioral intervention (EIBI) curricula, in which echoic and tact training is typically emphasized before reading. Ingvarsson and Hollobaugh (in press) compared vocal and picture prompts with three 4-year-old boys with autism, and found that although both prompting tactics were effective, the picture prompts were more efficient (as measured by the number of trials to criterion). The participants were students at an eclectic autism treatment center, and had not received EIBI.

Whereas research on the efficiency of prompting tactics has typically shown one prompt modality to be more efficient than the other, more than one prompting tactic has typically been effective. Slight initial differences in efficiency might not be the most important consideration in choosing between prompting tactics. Another potentially important variable is student preference for prompting tactics. Preference for instructional or treatment contexts can be evaluated using concurrent-chains arrangements (Hanley, 2010). Concurrent chains are an experimental arrangement in which participants are exposed to two or more response options in an *initial link* (e.g., differently positioned response keys or colored cards). A response to a particular option leads to an associated *terminal link,* each of which contains different contingences or contexts (e.g., different reinforcement schedules or antecedent manipulations). Response patterns in the initial link can be viewed as indicative of *preference* for the terminal link conditions (Catania, 1998). As an example of a recent use of a concurrent-chains arrangement, Geiger, LeBlanc, Dillon, and Bates (2010) evaluated preference between in vivo and video modeling with three children with autism. They found no differences in preference for any of the participants. Concurrent-chains arrangements have also been used both with typically and atypically developing children to evaluate preferences for behavior reduction strategies (e.g., Hanley, Piazza, Fisher, Contrucci, & Maglieri, 1997) and instructional contexts (e.g., Heal, Hanley, & Layer, 2009).

The first goal of the current study was to replicate the Ingvarsson and Hollobaugh (in press) study with four children with autism who had experienced several months of behavioral intervention, in which extensive use had been made of vocal prompts (e.g.,

Table 1
Age, Time in Program, and Standard Scores for All Participants. WPPSI-III: Wechsler Preschool and Primary Scale of Intelligence-III; PPVT: Peabody Picture Vocabulary Test—Fourth Edition; EOWPVT: Expressive One-Word Picture Vocabulary Test

			Standard Scores		
Name	Age (year-month)	Time in program (months)	WPPSI-III(IQ)	PPVT-IV (receptive language)	EOWPVT (expressive language)
David	5–0	7	54	70	63
Gary	3–6	5	81	58	77
Andrew	7–5	8	47	66	61
Rick	5–0	7	63	63	61

echoic-to-tact transfer). In addition to vocal and picture prompts, textual prompts were used with one of the participants in the current study. A second goal was to evaluate the effects of repeated exposure to the prompting tactics. We hypothesized that with repeated exposure, initial differences between prompting tactics might be reduced. To evaluate this possibility, intraverbal training was repeated with different questions following mastery of the initial training set. A third goal of the current study was to evaluate the feasibility of a concurrent-chains arrangement to evaluate preference for prompting tactics in intraverbal training.

METHOD

Participants

Four boys, David, Gary, Andrew, and Rick, participated. They had all been diagnosed with autistic disorder by independent clinicians and attended a center-based behavioral autism treatment program two days (David, Andrew, and Rick) or five days (Gary) per week. David and Rick were dizygotic (i.e., fraternal) twins. David, Rick, and Gary were Caucasian, and Andrew was African American. Table 1 shows the participants' ages, time they had attended the program when they entered the study, and results of standardized tests that were conducted after they entered the program but before the start of the study.

The participants were nominated by the supervising behavior analysts at the center because of delays in the development of question-answering and conversational skills. A snap-shot of the participants' skill level at the beginning of the study was obtained by inspecting their individualized curriculum-based assessment and tracking file. David had mastered single-word mands, could follow routine instructions, and was able to receptively identify and tact various common objects (e.g., body parts, animals, food, furniture, vehicles), but only one abstract concept (colors). He had mastered two intraverbal programs: Answering questions regarding animal sounds and completing statements (i.e., filling in the blanks) describing preferred activities. David was also observed to engage in immediate echolalia.

Gary had good vocal manding skills, was able to follow one-step instructions, receptively identify and tact common objects (e.g., body parts, clothing, familiar people), and common concepts (size, color, shape). Gary had mastered the same intraverbal programs as David, with the addition of filling in words from songs.

Andrew had solid manding skills, and his tacting and receptive language (i.e., listener) repertoires were more extensive than the other participants. In addition to the tact and listener skills programs that the others had mastered, he was also able to identify objects by function, point to items in complex pictures, identify environmental sounds, possessive pronouns, and was able to demonstrate actions when instructed. He had mastered ''say vs. do'' discrimination, and had mastered the concept of ''same vs. different.'' He was able to tact alphabet letters, rooms, and ongoing live actions. He

also reliably engaged in spontaneous greetings. However, Andrew had only mastered one intraverbal program: rote counting.

Rick had mastered single-word mands, could follow one-step instructions, and was able to receptively identify and tact various common objects (e.g., body parts, animals, food, furniture), as well as two abstract concepts (colors and shapes). Like David, he had mastered two intraverbal programs (answering questions regarding animal sounds, and completing statements describing preferred activities) and was observed to regularly engage in immediate echolalia.

Setting

All sessions (except generalization probes, see below) were conducted in a large room in the treatment center the children attended. The room was 23 by 18 m in area, and 3.7 m floor to ceiling. The room contained six partitioned teaching areas in which the participants and other children enrolled in the treatment center received one-to-one individualized tutoring. The rest of the room was divided into play areas containing a variety of toys, and also contained a TV (with access to various video games) and a computer station (with access to educational computer games). The room held 4–6 children (each with an accompanying tutor) at a given time. The sessions were conducted in the partitioned areas, with enough distance between the participants so they would not overhear each other's responses or the experimenter's prompts. In between sessions, the participants engaged in a play activity of their own choosing in the room. Generalization measures were collected in the hallways of the center.

Materials

Stimulus cards were used in the textual and picture prompting conditions, as well as the textual and tact pretests. The stimulus cards were made of white construction paper, and were 13 by 18 cm in area. Each textual card contained an answer to one of the target questions (e.g., COW) printed in black 100 point Times New Roman font on one side of the card. Each picture card contained a picture representing one of the correct answers (e.g., a picture of a cow) glued on one side. The pictures were approximately 8 by 12 cm in area (size varied somewhat between cards). In the concurrent-chains assessment, the initial link consisted of the presentation of colored cards, approximately 12 by 15 cm, mounted horizontally on a white poster board, 50 by 75 cm in area.

Measurement and Interobserver Agreement

Observers scored occurrence of prompted and unprompted correct answers using pencil and paper. Data sheets were arranged for each session, specifying the question to be asked, the correct answer, and the order in which the questions were to be asked. Correct unprompted answers were defined as answers matching the answers specified on the datasheet that were not preceded by a textual, picture, or vocal prompt. To be counted as correct, the participants had to emit the answer within 5 s of the question. Correct prompted answers were defined in an identical manner, except these answers had to occur within 5 s of the presentation of a textual, picture, or vocal prompt.

A second observer independently collected data for 42.9% percent of sessions for David, 53.0% for Gary, 36.8% for Andrew, and 46.8% for Rick. An agreement was counted if the scoring on a given trial was identical; otherwise a disagreement was scored. Interobserver agreement (IOA) was calculated by dividing the number of agreements in each session with the total number of trials in that session. IOA averaged 97.6% (range, 66.7%–100%) for David, 98.5% (range, 71.4%–100%) for Gary, 98.9% (range, 77.8%–100%), for Andrew, and 99.5% (range, 86.7%–100%), for Rick.

Procedures

General procedure and order of conditions. We conducted 3–6 sessions per day on each day the participant attended the center, with 1–2 min breaks between sessions. The duration of each session was approximately 3–5 minutes. During each session the experimenter and the child sat at a child-sized table, and a second observer was present during some sessions. The experimenter delivered general praise contingent on ap-

propriate session behavior (sitting, orienting toward the experimenter) at least once per session.

Each participant progressed through the following sequence of experimental conditions: Intraverbal pre-test, textual pre-test, tact pre-test, echoic pre-test, intraverbal training baseline, pre-intervention generalization probe (for the first intraverbal training phase), intraverbal training (first comparison), post-intervention generalization probes, color preference assessment, baseline, pre-intervention generalization probes (for the second intraverbal training phase), intraverbal training (second comparison), concurrent-chains assessment (simultaneous with intraverbal training), post-intervention generalization probes, follow-up concurrent-chains assessment (David, Gary, and Rick only), and maintenance probes.

Intraverbal, textual, tact, and echoic pretests. We identified 51 questions whose answers could be prompted textually, vocally, and pictorially. We then conducted an intraverbal pre-test to identify unknown questions for each participant. Each question was asked three times over the course of 3 days; correct answers were praised and incorrect answers were ignored. The questions that were answered incorrectly every time were considered unknown for that participant. Other questions were discarded.

Textual, tact, and echoic pretests were conducted for all 51 questions. Each pre-test consisted of the presentation of each item one time, resulting in 51 trials for each pre-test. In the textual pre-test, the experimenter held a text card in front of the child and said, ''Read this.'' In the tact pre-test, the experimenter held a picture card in front of the child and asked, ''What is this?'' In the echoic pre-test, the experimenter said, ''Say____,'' with the blank representing a target answer (e.g., ''say, cow'').

In all of the pretest trials, the experimenter allowed the participants a maximum of 10 s to respond. If an incorrect answer (or no answer) occurred within 10 s the experimenter said nothing and moved on to the next item. If a correct answer occurred within 10 s, the experimenter provided descriptive praise (e.g., ''that's right, that's a cow'') and moved on to the next item. Note that the questions to be targeted during intraverbal training (e.g., ''what animal says moo?'') were not presented during the textual, tact, or echoic pretests.

Unknown questions were assigned to the textual, picture, or vocal prompt conditions only if the participants were able to respond textually (read), echo, or tact the relevant answers. Assignment of questions to sets was therefore based on responding in the intraverbal, textual, tact, and echoic pretests. Each set consisted of five questions. An attempt was made to assign questions to sets such that each set would contain questions of approximately equal complexity. The questions assigned to each set for each participant are shown in Table 2. The participants' supervising behavior analysts agreed to not teach the participants answers to these questions in extra-experimental instructional sessions during the course of the study.

Baseline. In baseline, each question in a given set was asked once per session; thus, each session consisted of 5 trials (a trial was defined as the presentation of a single question). Correct answers were praised and incorrect answers ignored.

Intraverbal training. The experimenter taught the participants to say the correct answer to each question using constant (5-s) prompt delay, descriptive praise for correct answers (prompted and unprompted), and either textual, picture, or vocal prompting. In the first session of the prompt comparison phase for each question set, the experimenter presented each question 3 times with an immediate prompt, resulting in a total of 15 trials. In each subsequent session, one trial with a 5-s constant prompt delay (these trials will henceforth be referred to as training probe trials) was implemented for each of the 5 questions. If a correct answer occurred within 5 s of the presentation of the question, the experimenter provided descriptive praise (e.g., ''that's right, a cow says moo'') sometimes along with a token (see below), and presented the training probe trial for the next question. If a correct answer *did not* occur, the experimenter provided the appropriate prompt. The textual prompt consisted of the experimenter presenting the textual card directly in front of the participant's face. The vocal prompt consisted of the experimenter stating ''say _____.'' In the picture prompt condition, the prompt consisted of the

Table 2
Question Sets for All Participants

Participants		Question Sets		
		Textual prompt sets	Picture prompt sets	Vocal prompt set
David	Set 1	What do you use to tell time?	What do chickens lay?	What makes the sound ‘‘beep beep’’?
		What animal says meow?	What do you take pictures with?	What do you throw or kick?
		What do you hear with?	What do apples grow on?	What do you bang with?
		What animal says moo?	What do you write with?	What do you eat with?
		What do you wear on your feet?	What do you use to cut paper?	What do you drink out of?
	Set 2	What do you sweep with?	What is ice made of?	What does a postman deliver?
		What do you sleep in?	What shines in the sky during the day?	What do you see with?
		What do you use when it rains?	What do you read stories from?	What do you listen to music on?
		What do you talk with?	What do you use to call people?	What do you wear on your head?
		What do you sneeze with?	What do you ride on outside?	What do you watch a movie on?
Gary	Set 1		What makes the sound ‘‘beep beep’’?	What does a postman deliver?
			What do you drink out of?	What do you wear on your hands?
			What do apples grow on?	What grows in a garden?
			What do you sneeze with?	What do you watch a movie on?
			What do chickens lay?	What is ice made of?
	Set 2		What do you use to tell time?	What do you dig with?
			What coin is worth one cent?	What do you bang with?
			What do you use to call people?	What do you take pictures with?
			What shines in the sky during the day?	What coin is worth 25 cents?
			What do you see at night in the sky?	What do you use to paint with?

Table 2, *cont.*

Participants		Question Sets		
		Textual prompt sets	Picture prompt sets	Vocal prompt set
Andrew	Set 1		What do you use to tell time?	What does a postman deliver?
			What coin is worth 25 cents?	What do you sweep with?
			What do you hear with?	What do you walk with?
			What do you bang with?	What coin is worth one cent?
			What shines in the sky during the day?	What do you use to paint with?
	Set 2		What do you talk with?	What animal has a long neck?
			What do you see with?	What state do you live in?
			What grows in a garden?	What do you dig with?
			What do you drink out of?	How does ice feel?
			What do you see at night in the sky?	What makes the sound ''beep beep''?
Rick	Set 1		What do you use to tell time?	What do you wear on your feet?
			What do chickens lay?	What do apples grow on?
			What do you write with?	What do you sneeze with?
			What do you see with?	What do you drink out of?
			What do you wear on your head?	What do you watch a movie on?
	Set 2		What is ice made of?	What do you sweep with?
			What do you blow your nose with?	What do you wear on your hands?
			What do you hear with?	What do you sleep in?
			What do you sit on?	What does a postman deliver?
			What do you use when it rains?	What do you use to paint with?

experimenter presenting the picture card directly in front of the participant's face. If a correct answer to the prompt occurred within 5 s of the prompt presentation, the experimenter provided descriptive praise and the trial ended. Otherwise, the experimenter re-presented the prompt once (by repeating the vocal prompt, or by pointing to the picture/text) and allowed an additional 5 s for an answer to occur.

If a correct independent answer did not occur in a given training probe trial, the experimenter immediately conducted two teaching trials for that question. The procedures for the teaching trials were identical to the training probe trial procedures except that the first teaching trial was always presented with an immediate prompt (0-s delay). If a correct response to the immediate prompt occurred, the second teaching trial was conducted using 5-s constant prompt delay; otherwise an immediate prompt was used again in the second teaching trial.

Thus, the number of trials in a session (excluding the first session in each prompting condition of the intraverbal training phases) could range from 5 (if all questions were answered correctly in the training probe trials) to 15 (if no correct answers occurred in the training probe trials). The mastery criterion for each prompting condition was set as three consecutive sessions with at least 80% correct answers on the training probe trials.

Initially, the questions in each set were always asked in the same order, but random question order was implemented after the intraverbal training mastery criterion had been met. Sessions continued until the participants answered at least 80% of questions correctly in at least two consecutive sessions in each prompting condition with random question order. In the second intraverbal training phase (in which the concurrent chains assessment was implemented, see below), sessions sometimes continued beyond this criterion in order to allow for continued assessment of choice.

Consequences for correct responses. The experimenter delivered praise for correct responses throughout all phases and conditions for all four participants. In addition, we delivered tokens, exchangeable for participant-selected preferred items and activities, for correct answers during some sessions. All four participants used token economies in their educational programming, and the extent to which we used token delivery in the current experiment depended on the participant's response patterns. David, Andrew, and Rick continued responding correctly when token delivery was thinned and then completely withdrawn, and token reinforcement was therefore only implemented in the first few sessions of the first intraverbal training phase for these participants. We continued to deliver tokens with Gary throughout both his intraverbal training phases, because his responding deteriorated when tokens were withdrawn. However, the generalization and maintenance probes were conducted with praise only for all participants.

Concurrent-chains assessment. The purpose of the concurrent-chains assessment was to evaluate preference for the prompting tactics. This was achieved by having the participants choose which prompting tactic would be used in the upcoming intraverbal training session. For three participants (Andrew, David, and Rick), a free-play condition was also included among the choice options as a control condition. The concurrent-chains assessment was implemented simultaneously with the second phase of intraverbal training, after the participants had already experienced the prompting tactics during the first phase of intraverbal training. The initial link response consisted of pointing to one of the cards. The terminal link consisted of the experimental conditions that were associated with each card, which included the picture prompt condition and vocal prompt condition for all participants, the textual prompt condition for David only, and a free-play condition (3 m of play with highly preferred toys) for David, Andrew, and Rick.

Depending on the number of conditions included with each participant, 2–4 cards were included in the initial link stimulus array presented to each participant. The cards were yellow, red, green, and blue. We conducted a paired choice color preference assessment using the colored cards with each participant prior to the experiment; the results revealed no pre-existing bias toward any color for any participant. Prior to each session, the experimenter described the prevailing contingencies to each participant while pointing to the relevant picture (e.g., ''when you point to the

blue card, I'm going to tell you the answers to the questions; when you point to the green card, I'm going to show you pictures with the answers to the question; when you point to the yellow card, you get to play''). With each initial link trial, the cards were rotated. During the terminal-link activities, the experimenter wore a lei whose color corresponded with that of the initial-link card.

During the first session in each condition of the second intraverbal training phase, we conducted forced-choice trials, in which the participants were prompted to pick the associated colored card prior to each session. The purpose of this step was to ensure that the participants experienced the association between the colors and the terminal link condition prior to the implementation of free-choice initial link trials. For David, Andrew, and Rick, we also conducted forced-choice initial link trials during the latter part of the first intraverbal training phase (the last 30 sessions for David and Andrew, and the last 10 sessions for Rick). An equal number of forced choice play sessions were conducted with each of these three participants. For Gary (who was the first participant that completed the experiment), we implemented two additional forced choice initial-link trials following the first 4 free-choice initial-link trials, in order to ensure that he had exposure to both prompting conditions.

The stimuli representing initial link options were permanently removed from the array if the following conditions were met: If the play condition was exclusively selected for 6 consecutive trials, the stimulus associated with that option was removed. If any other condition was selected for 6 consecutive trials, the stimulus associated with that condition was also removed, but only if the mastery criterion had been reached with that stimulus set. Otherwise, the option was removed from the array when the participant reached the mastery criterion, provided that responding was still exclusively allocated to that option. A second set of removal criteria was also in effect: An option was to be removed if it occurred for more than 75% over 10 consecutive trials, provided mastery criterion had been met. However, this criterion was not applicable to the data patterns observed in the current study.

Concurrent-chains assessment: Follow-up investigation. Clear preferences did not emerge in the concurrent-chains assessment for Gary, David, or Rick. Therefore, we conducted follow-up assessments in order to evaluate whether the arrangement was capable of detecting preferences using items that had functioned as reinforcers in the past. We selected high, medium, and low preference items or activities based on clinical experience. The high preference (HP) items or activities had been observed to be effective reinforcers in multiple instructional programs. For David and Rick, the HP option was three min access to an indoor gym, which contained multiple activities (e.g., ball-pit, swing, train-set). During the assessment, access to the indoor gym was represented via a picture card. For Gary, the HP option was a choice of a single edible item from a variety of preferred edibles. The medium preference (MP) items were activities that the participants would engage in for several minutes if instructed to do so, but had not been observed to actively seek out in the past. For David and Rick, the MP items were a crayon and a blank piece of paper and for Gary the medium preference activity was a worksheet from a direct instruction curriculum (implemented by the tutor assigned to Gary that day). The low preference (LP) items were stimuli that the participants were not likely to engage with voluntarily (informal probe sessions were conducted to ensure that this was the case). For David and Rick, the LP items were two wooden blocks, and for Rick, the LP item was an empty box. In all trials, three-m access was given to each item/activity when selected. If the participants didn't interact with the LP items for 30 s, the trial was terminated and the next trial was implemented. Otherwise, this assessment was identical to the original concurrent-chains assessment. The restriction/removal criteria were also identical, except that the mastery criterion was not applicable.

Generalization and maintenance probes. A generalization probe was implemented with each question set prior to and following intervention. The procedures were identical to baseline, except that a different person (a behavior analysis intern not otherwise directly involved in the study) conducted each probe session while taking a walk with the participants in the hallway of the center. One of the experimenters supervised each gener-

alization probe session to ensure procedural integrity.

Maintenance probes were conducted with three of the participants (due to a scheduling mistake, maintenance data were not collected for Andrew). The procedures during maintenance probes were identical to baseline. The interval between the end of the study and the maintenance probes varied somewhat due to participant availability (i.e., summer breaks intervened). David's maintenance probes were conducted 18 and 14 weeks after the completion of the first and second intraverbal training phase, respectively. Gary's maintenance probes were conducted 12 and 8 weeks after the completion of the first and second intraverbal training phase, respectively. For Rick, maintenance probes were conducted 9 and 5 weeks following the completion of the first and second intraverbal training phase, respectively.

Experimental Design

We compared intraverbal training using textual, picture, and vocal prompts within participants in an adapted alternating treatment design (Sindelar, Rosenberg, & Wilson, 1985), and evaluated the effects of prompting over baseline across participants in a nonconcurrent multiple baseline design. Two successive intraverbal training phases were conducted with each participant, using different question sets. A baseline was established with the second set before the second intraverbal training phase was implemented. During the first intraverbal training phase, session order was determined semi-randomly (i.e., no condition could occur for more than two consecutive sessions). During the second intraverbal training phase, a concurrent-chains assessment (see above) was implemented simultaneously with the prompt comparison to evaluate preference for prompting tactics. The order of sessions in that phase was determined by the participants' initial link selection responses.

RESULTS

Pretests

The intraverbal pre-tests resulted in the identification of 51, 30, 24, and 42 unknown questions for David, Gary, Andrew, and Rick, respectively. On the textual pretest, David read 16 out of 51 words correctly, and Andrew read 6 out of 51 correctly, while Gary and Rick scored zero correct. On the tact pretest, David, Gary, Andrew, and Rick had 36, 35, 43, and 37 items correct respectively. In the echoic pretests, all four participants were able to echo 100% of the vocal models presented. Thus, only David had enough correct answers on the pre-test for a comparison between all three prompting tactics to be possible. For the other participants, only vocal and picture prompts were compared.

Intraverbal Training

The results of the intraverbal training are displayed in Figure 1. Only training probe data are shown (i.e., teaching trial data are not shown). No correct answers occurred in either of the two baselines. In the first intraverbal training phase, David (top panel) quickly showed evidence of acquisition across all three conditions, but the number of correct answers was initially slightly lower in the textual prompt condition compared with the other two conditions. In the second intraverbal training phase, responding was similar across the three conditions, but acquisition was overall slower than in the previous phase.

Gary (Figure 1, second panel) showed quick acquisition across both vocal and picture prompt conditions in the first intraverbal training phase, and visual inspection of training probe data shows no difference between the two conditions. During the second intraverbal training phase, more correct answers occurred initially in the picture prompt set condition, but responding was variable and overall acquisition was slower than in the first intraverbal training phase.

During the first intraverbal training phase, Andrew (Figure 1, third panel) initially engaged in a greater number of correct answers in the picture prompt condition. However, responding in the vocal prompt condition increased steadily and the mastery criterion was reached sooner in that condition. In the second intraverbal training phase Andrew's acquisition patterns were virtually

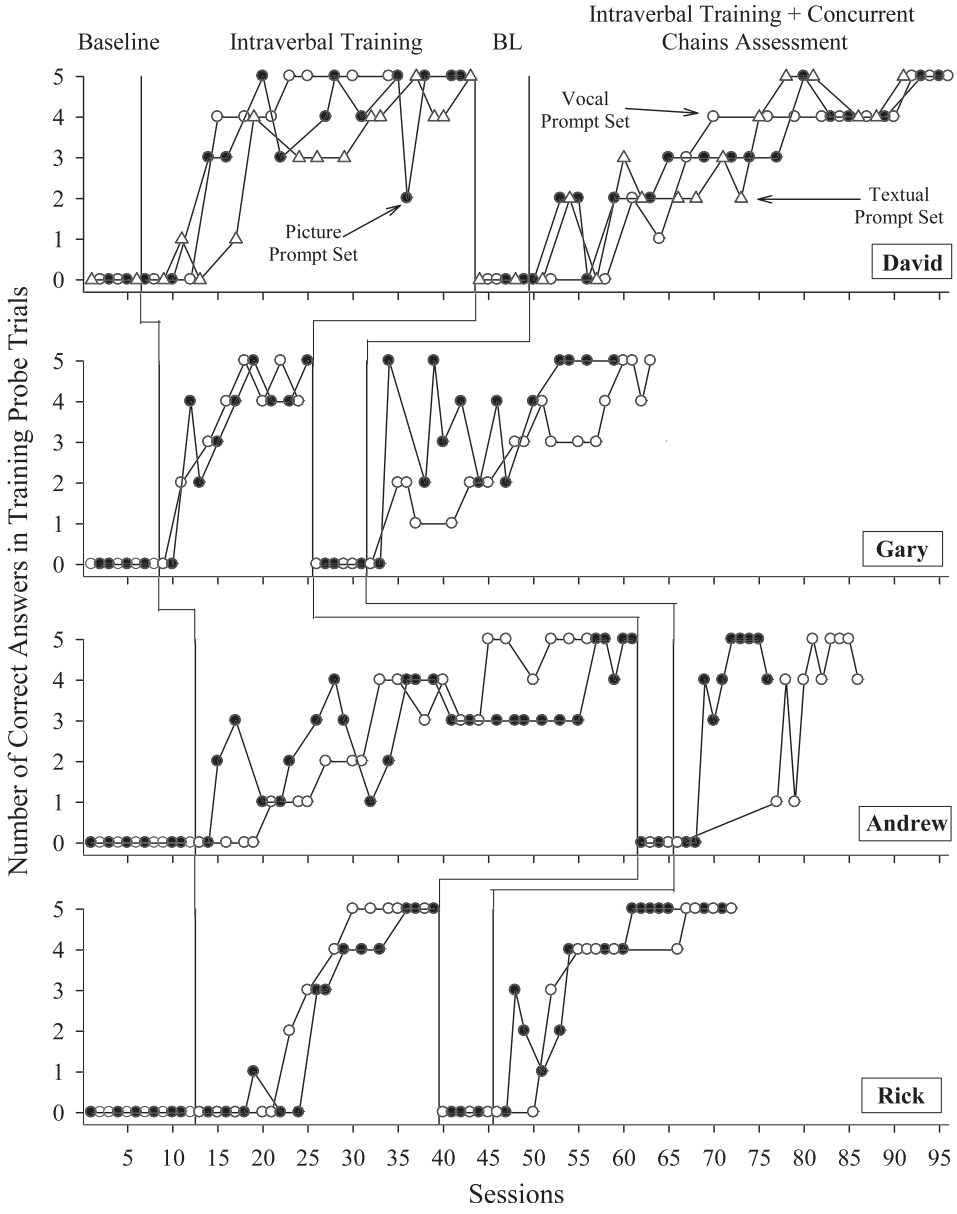

Figure 1. The number of correct responses in training probe trials for David, Gary, Andrew, and Rick during intraverbal training. Question sets numbered 1 (see Table 2) were used in the first baseline and intraverbal training phase, and question sets numbered 2 were used in the second baseline and intraverbal training phase.

identical across the two conditions. Unlike David and Gary, Andrew reached mastery in fewer sessions in the second intraverbal training phase. Andrew reached mastery first in the picture prompt condition because his initial link responding was exclusively allocated to that option in the concurrent-chains assessment (see below).

Rick (Figure 1, fourth panel) didn't show consistent evidence of acquisition until several sessions into the first intraverbal training phase. However, subsequent acquisition was rapid and approximately equal across vocal and picture prompts. In the second intraverbal training phase, acquisition was more immediate, and Rick achieved the

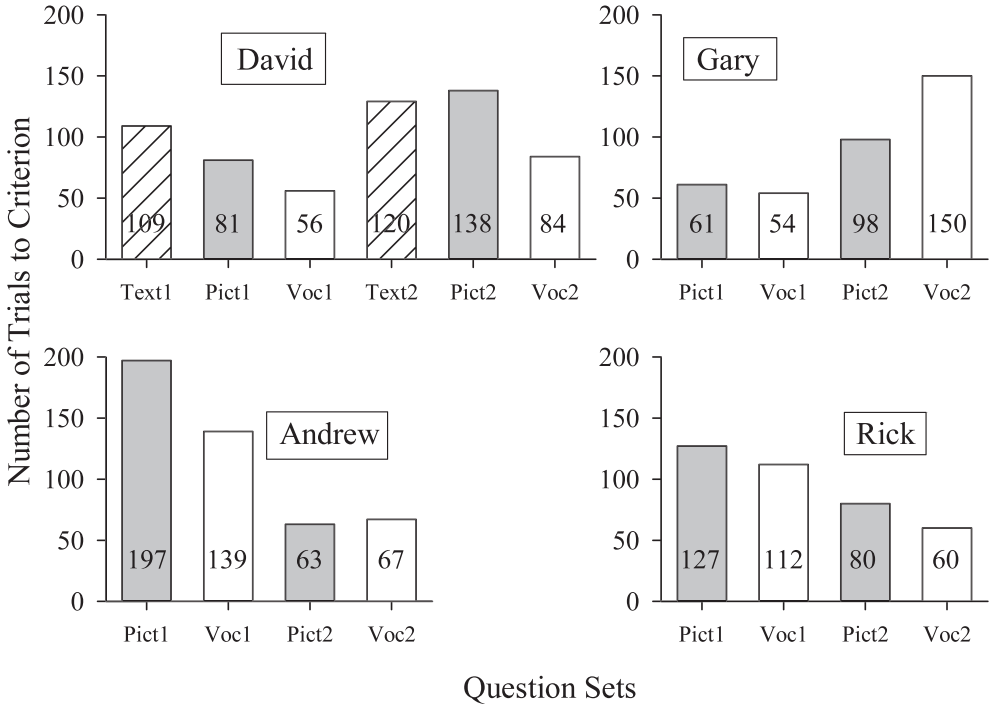

Figure 2. Trials to criterion for all question sets for David, Gary, Andrew, and Rick. Question sets numbered 1 (left half of each panel) were used in the first intraverbal training phase, and question sets numbered 2 (right half of each panel) were used in the second intraverbal training phase.

mastery criterion earlier in the vocal prompt condition.

Figure 2 shows the trials to criterion for all participants across all prompting conditions. Trials to criterion were calculated by adding up all trials (both training probe trials and teaching trials) starting with the first session in the intervention phase and ending with the session in which the mastery criterion was reached. Figure 2 shows that for the first intraverbal training phase (i.e., the bars on the left side in each panel) all the participants reached the mastery criterion in fewer trials in the vocal prompt condition. The difference was large for David and Andrew, but smaller for Gary and Rick. This finding was replicated in the second intraverbal training phase (i.e., the bars on the right in each panel) for David and Rick. However, in the second intraverbal training phase, both Gary and Andrew required more trials to reach the mastery criterion in the vocal prompt condition compared with the picture prompt condition (although the difference in Andrew's case was small). The second main finding to be gleaned from Figure 2 pertains to the overall difference in trials to criterion between the first and second intraverbal training phases. For David and Gary, more trials were needed during the second intraverbal training phase in all conditions, but for Andrew and Rick, fewer trials were required in the second intraverbal training phase in both conditions.

Concurrent Chains Assessment

The results of the concurrent-chains assessment are shown in Figure 3. No differences in cumulative initial link selections were seen for David and Gary; hence, no initial link option was removed from the array for these participants. Andrew, however, initially allocated all of his responding to the free-play condition. Following six consecutive play condition selections, this option was moved from the array. Andrew then consistently selected the picture prompt condition, and that option was removed from the array when both removal criteria had been met (i.e., at least six

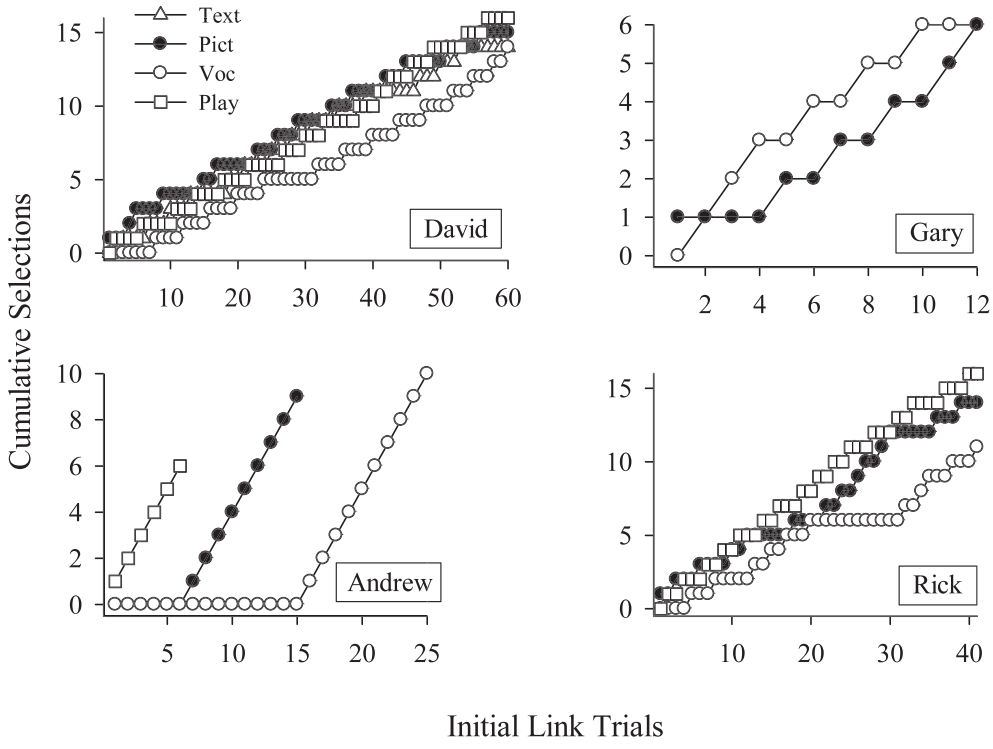

Figure 3. Cumulative initial-link selections during the original concurrent-chains assessment (conducted simultaneously with the second intraverbal training phase), for David, Gary, Andrew, and Rick.

consecutive selections, and acquisition mastery criterion met). The only remaining option was then the vocal prompt condition, and Andrew selected that option until he had reached the mastery criterion. Rick's selection pattern was mostly undifferentiated and similar to David's and Gary's. However, he refrained from selecting the vocal prompt condition for 12 consecutive trials, during which he allocated his responding approximately equally to the play and picture prompt condition. Following the 12-trial pause, Rick selected the vocal prompt condition in approximately equal proportion to the other conditions. As with David and Gary, no initial link option was removed from the array during Rick's initial concurrent-chains assessment.

The results of the follow-up concurrent chains assessment are presented in Figure 4. No differentiated responding was seen for David and Gary. However, after an initial period during which Rick alternated between the response options, he began selecting the high preference condition exclusively. Following six consecutive selections, the high preference option was removed from the array. For the remainder of the assessment, Rick's initial link responses alternated between the medium and low preference options.

Generalization and Maintenance Probes

No correct answers occurred in any of the generalization pre-tests (data not shown). The results of the post-intervention generalization probes are shown in Table 3. All participants answered either 4 or 5 questions correctly in the probes (with the exception of David's second textual set). The results of the maintenance probes are shown in Table 4. Gary and Rick answered either 4 or 5 questions correctly in each maintenance probe, with the exception of Rick's first picture prompt set. David's maintenance probe results, on the other hand, were more variable, and ranged from 1 to 4 correct.

DISCUSSION

We compared prompting tactics to establish intraverbal responding (i.e., question-

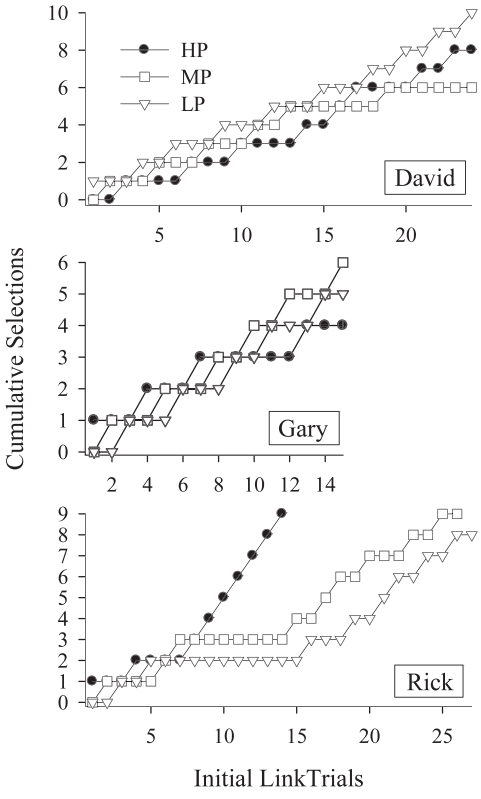

Figure 4. Cumulative initial-link selections during the follow-up concurrent chains assessment for David, Gary, and Rick. HP: High Preference option; MP: Medium Preference option; LP: Low Preference option.

answering) in four boys with autism. Based on pre-tests, we compared picture prompts and vocal prompts with Gary, Andrew, and Rick, and textual, picture, and vocal prompts with David. For all participants, vocal prompts were the most efficient prompting tactic during the first intraverbal training phase. This outcome is inconsistent with the findings of Ingvarsson and Hollobaugh (in press), who found that picture prompts were more efficient than vocal prompts for three boys with autism. Because the instructional strategies in the two studies were highly similar, the reason for these discrepant results might be differences in participant histories with respect to different prompting strategies. The three participants in the Ingvarsson and Hollobaugh study attended an eclectic center for the treatment and study of autism, in which they experienced a variety of intervention strategies. Although their instructional history is not fully known, we do know that only a portion of the time at the center was spent on learning skills taught with behavior analytic procedures (e.g., discrete trial teaching and incidental teaching). The participants in the current study, on the other hand, had been enrolled for several months in a behavior analytic autism intervention program directed by the authors of this report. Almost all their hours in the program had been spent in behavior analytic instructional strategies, including an emphasis on strategies utilizing transfer-of-control prompting procedures. Vocal prompts had been used extensively for all four participants. It seems likely that through their experience with vocal prompts, the participants had acquired responses that enabled relatively efficient transfer of control from vocal prompts to alternative verbal antecedent stimuli (i.e., echoic to intraverbal transfer). One of these acquired responses might include overt or covert echoing to ''bridge the gap'' from the presentation of the prompt until the next opportunity to respond in the absence of the prompt. To the extent that these responses occur covertly, such self-echoic responding might be considered examples of covert problem solving (Palmer,

Table 3
Number of Correct Answers (Out of Five) on Post-Intervention Generalization Probes for All Participants. All Participants Scored Zero in Every Pre-Intervention Generalization Probe

	Textual prompt sets		PictSSure prompt sets		Vocal prompt sets	
Name	Set 1	Set 2	Set 1	Set 2	Set 1	Set 2
David	4	3	4	4	5	4
Gary	–	–	5	5	5	5
Andrew	–	–	5	4	4	5
Rick	–	–	4	5	4	4

Table 4
Number of Correct Answers (Out of Five) on Maintenance Probes for All Participants. Maintenance Probe Data Were Not Collected for Andrew

	Textual prompt sets		Picture prompt sets		Vocal prompt sets	
Name	Set 1	Set 2	Set 1	Set 2	Set 1	Set 2
David	3	2	3	1	4	2
Gary	–	–	4	5	4	5
Rick	–	–	2	4	4	4

1991). The potential facilitative effect of history is consistent with the results of Coon (2010), who found that acquisition was facilitated as a function of recent experience with particular prompting tactics. Future research should evaluate the effects of directly teaching responses (e.g., self-echoic responding) that might facilitate transfer of stimulus control in intraverbal training. This is especially relevant because recent evidence suggests that this skill might be deficient in children diagnosed with autism (Esch, Esch, McCart, & Pétursdóttir, 2010).

For David, textual prompts were the least effective prompting tactic during the first intraverbal training phase. This finding is inconsistent with the results of Finkel and Williams (2001) and Vedora et al. (2009), who found textual prompts to be more efficient than vocal prompts. However, this finding is consistent with the results of Cook et al. (2010), who found that vocal prompts were equally or more effective than textual prompts in intraverbal training. The current comparison is limited because only one participant with a limited textual repertoire (i.e., he could only read 16 of 51 words presented during the pretest) experienced the textual prompt condition. A recent study by Emmick, Cihon, and Eshleman (2010) suggested that reading fluency might increase the effectiveness of textual prompts in intraverbal training in some cases. David's reading fluency is unknown but may have been lacking. Nevertheless, the current results support the general notion expressed by Cook et al. that textual prompts are not necessarily more efficient than vocal prompts with children with autism.

In the second intraverbal training phase, Andrew and Rick reached the mastery criterion in fewer trials across both conditions, compared with the first intraverbal training phase. For Andrew, the difference in efficiency between the two prompting tactics all but disappeared in the second intraverbal training phase, but for Rick, the vocal prompt condition was again more efficient than the picture prompt condition. David and Rick, on the other hand, reached the mastery criterion in a greater number of trials across both conditions during the second intraverbal training phase. These results offer equivocal support for the hypothesis that history of transfer of stimulus control using a particular prompt modality facilitates subsequent acquisition with that prompt, as suggested by Coon (2010). However, it is worth noting that the two participants (Andrew and Rick), for whom a beneficial effect of recent prompting history was suggested, were also the two participants who required the greatest number of trials to criterion during the first intraverbal training phase. Thus, it might be the case that beneficial effects of history are most likely to be apparent with students who show relatively slow initial transfer of stimulus control.

The response patterns for the two participants who showed slower acquisition in the second intraverbal training phase (i.e., Gary and David) differed somewhat. Gary showed quick acquisition in the first intraverbal training phase and inconsistent performance in the second training phase. Because his performance deteriorated following the first few sessions of the second training phase, it seems possible that a loss of reinforcer effectiveness may have adversely affected his motivation to respond during portions of the second training phase. This explanation does not, however, fit David's results, which reflected no such inconsistency in performance. It may be that David would have benefitted from additional exposure to the

prompting tactics, particularly considering the fact that he experienced a greater number of prompting tactics than the other participants, and he therefore had to learn a greater number of discriminations. The different number of prompting tactics evaluated across participants may be viewed as a limitation of the current investigation when it comes to evaluating the effects of history.

The intraverbal responses acquired with each prompting tactic generalized across people and settings, suggesting that the responses were under stimulus control of the antecedent verbal stimulus, and not other aspects of the instructional context. In the maintenance probes, Gary and Rick answered 4 or 5 questions correctly for each set, with the exception of Rick's first picture prompt set. Maintenance probe results, however, were less consistent for David. This is not surprising in light of the fact that David learned a greater number of intraverbal responses than the other participants, and his maintenance probes were conducted after a longer delay.

The concurrent chains assessment revealed a clear preference only for Andrew, who preferred free play over either prompting tactic. When the free play option was removed, Andrew consistently preferred picture prompts over vocal prompts. Andrew thus preferred the prompting tactic that had been less efficient in the first intraverbal training phase, although that difference in efficiency had disappeared by the time of the second intraverbal training phase. It is unknown why Andrew preferred picture prompts over vocal prompts, but it is possible that Andrew generally preferred visual stimuli over auditory stimuli.

A consistent preference was not observed during the concurrent chains assessment for the other three participants. Gary was the first participant to enter this phase of the assessment. When his initial-link data showed no differentiation, it became apparent that we could not determine whether this result was due to a true lack of preference, or whether the arrangement might be insensitive. To help assess this possibility, a free play condition was added for the other three participants (cf. Heal & Hanley, 2007). During free play, the participants could choose to engage in a variety of preferred activities, and the free play area contained multiple materials that each of the participants had been observed to engage with voluntarily in the past. We therefore hypothesized that a considerable portion of the participants' initial-link responses would be directed toward the free-play option in the initial stages of the concurrent-chains assessment, and this response pattern might validate sensitivity with regards to activity preferences. While this occurred with Andrew, no reliable differences were detected with David and Rick. It is therefore unknown whether their initial-link selection pattern represented true indifference or the inability of the concurrent-chain arrangement to detect existing activity preferences.

Thus, the follow-up assessment was designed to explore this issue further. We chose the activities and stimuli in this phase of the assessment in accordance with previously observed preferences and reinforcer effectiveness. However, only Rick's responding was differentiated, with a clear preference for the high-preference option, and indifference between the medium- and low-preference options. This suggests that the current concurrent-chains arrangement was at least somewhat sensitive to existing preferences for Rick. However, it is possible that the arrangement only became sensitive to existing preferences during the course of the follow-up assessment, and that previously Rick's selections were locked in an alternating pattern (an alternating pattern might also have occurred with David and Gary). During forced choice trials, the experimenter prompted an alternating selection pattern. When free choice was implemented the alternating pattern might have continued due to the exposure to the forced choice trials, and intermittent reinforcement via access to high-preference options might have been sufficient to maintain the alternating response pattern. Future research should explore ways to design exposure to terminal links in a manner that does not establish alternating selection patterns. This could, for instance, be done by systematically programming random, unpredictable forced-choice patterns prior to the introduction of free choice trials. This line of research is important because it might enable valid ongoing assessment of play activities and

instructional strategies with individuals that have limited verbal skills (Hanley, 2010). This is especially relevant for activities that cannot be easily represented visually, and must therefore involve initial link stimuli such as colored cards that are arbitrarily related to the terminal link.

The accumulating data on prompting tactics in intraverbal training indicate that their efficiency is idiosyncratic across participants and suggest that prompts should be selected on an individual basis for each student, based on existing repertoires and history with the use of prompts. For instance, textual prompts might be indicated for students that are fluent readers and display a preference for textual stimuli. Picture prompts might be indicated for students that have a strong picture-tacting repertoire and limited history with echoic-to-intraverbal transfer. Vocal prompts might be indicated with students that have limited tact and textual repertoires, or have limited history with tact-to-intraverbal transfer. In addition, student preference should be taken into account as appropriate. However, these tentative guidelines should not be taken as absolute and ongoing assessment of student learning during intraverbal training will continue to be of primary importance. Ultimately, long-term intervention goals should aim at enabling students to learn novel intraverbal responses through all three modes of transfer of stimulus control.

Nevertheless, relevant concerns exist that are independent of student histories. On the one hand it may be argued that vocal prompts are the most practical and convenient method to teach intraverbal responses, because they require no materials or preparation. On the other hand picture prompts may be said to be the least practical, not only because their use requires materials and preparation (as is the case with textual prompts), but because not all intraverbal responses can be easily prompted through pictorial representations (e.g., some abstract concepts). Nevertheless, picture (and other visual) prompts have the advantage of increasing the probability of ''meaningful'' responses because relations between listener, tact, and intraverbal repertoires might be established through such training (Sundberg & Partington, 1998). If intraverbal responses are trained only through the use of vocal or textual prompts (without relations being established with tact and listener repertoires in some manner) the resulting responses may be ''rote;'' that is, only under the control of antecedent verbal stimuli, and not corresponding nonverbal stimuli. Future research should explore ways to establish relations among listener, tact, and intraverbal repertoires.

A few additional limitations of the current study are worth noting. First, the comparison of prompting tactics in the current study was limited because question complexity and difficulty was not precisely equated across question sets. It is possible that the question sets differed in terms of the stimulus discrimination complexity required to learn the answers. As an example, David's textual set included two animal sound questions, which are typically among the earliest intraverbal responses acquired by typically developing children. Another limitation is that it is not known to what extent the participants were able to respond as listeners or tact the component stimuli that comprised the questions. Previous learning histories with respect to those stimuli could have influenced the acquisition of some answers. A third limitation is that due to the varying topographies of the questions that comprised the target sets, we cannot be certain which elements of the questions gained stimulus control over responding. For instance, although Rick was able to answer the question ''What coin is worth 25 cents?'' when interspersed with topographically dissimilar questions, we do not know if he had been able to answer the question correctly if it had been interspersed with other questions that differed only in terms of one critical element (e.g., ''What coin is worth 5 cents?'' ''What coin is worth 10 cents?''). Thus, we do not know which word or combination of words in each question evoked the correct answer. These limitations could be minimized in future research by using stimulus sets that allow researchers to equate stimulus complexity and the number of potential simple and complex discriminations involved, and to control for participant's histories with respect to the stimuli.

Finally, the current arrangement did not allow us to demonstrate conditional stimulus control over intraverbal responding (Axe,

2008; Sundberg & Sundberg, in press). Conditional stimulus control occurs when a stimulus evokes different responses depending on the presence or absence of other stimuli. To illustrate, consider the following four questions: ''What do you sweep?'' (floor) ''What do you sweep with?'' (broom) ''What do you wash?'' (hands) ''What do you wash with?'' (soap). These questions differ in terms of two elements: The presence of the words ''sweep'' versus ''wash,'' and the presence versus absence of the word ''with.'' These two elements overlap such that four combinations of stimuli are created. Therefore, if these four questions are randomly interspersed, correct responding cannot be based on the presence and absence of a single element, but must be based on the combination of elements. Because verbal conditional discriminations play a great role in advanced intraverbal behavior, the development of instructional technology to establish such discriminations is a priority for future research.

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